DISCUSSION PAPER

COMPUTERS IN EDUCATION: A COLLEGE PERSPECTIVE

Ministry of Post-Secondary Education

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Discussion Paper

COMPUTERS IN EDUCATION:
A COLLEGE PERSPECTIVE

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Ministry of Post-Secondary Education
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July 2, 1986

Dr. John Dewey
Deputy Minister
Ministry of Post Secondary Education
818 Fort Street
Victoria, BC
V8V 1X4

Dear Dr. Dewey:

Re: **Computer-Based Education**

I can think of no field where advice has a shorter life span than the field of computer-based education. As each week passed your committee worried that a computer manufacturer, a software engineer or a sumptuously funded university would ring in a new generation of technology before we could rush into obsolete print. During our discussions we have tried to avoid an approach to the topic that was tied to equipment or to a simple faith in technology. The result is that we focus on advice to you which emphasizes the human and institutional context into which technology now so completely intrudes.

Computers and their associated information linking systems are in the process of being incorporated into both the content and process of education. Computing power is enabling teachers and students alike to reach for new learning strategies and to approach new questions. Computers are being adapted as tools into most fields from engineering to art, from nursing to creative writing. Incorporation of computing capacity into all sectors of education is so well advanced that any provincial policy must recognize the rapid pace of continuing development. Your committee recommends a balance between two necessities, central coordination of effort and institutional freedom to experiment. We advocate deliberate plans to create individual access to computing power for students and teachers and we advocate intensive cooperation among developers to ensure attention to economy. We advocate institutional arrangements that will assist faculty to adapt computing technology to their own educational purposes.

...../2

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July 2, 1986

Dr. John Dewey
Deputy Minister
Ministry of Post Secondary Education

In the last analysis, we believe that swift communication among enabled practitioners is the most flexible response to such a rapid field of development. While a great deal of money has already been spent and much more will be committed, our report is not primarily concerned with amounts of funds. It is concerned with the collaborative arrangements which are necessary to use our funds wisely to achieve appropriate educational objectives.

Yours truly,

Bruce Fraser

Bruce Fraser
Chairman, Computer-Based Education Committee

BF:rmh
cc: Members of the Committee
Grant Fisher
Lorne Thompson

Chapter 1

SUMMARY AND RECOMMENDATIONS

We are in the midst of yet another major change in the way our society functions. From an agricultural society, we have moved through the industrial revolution and are now entering what has come to be known as the "information age". The main force driving us into the information society is the computer revolution. Once found only in the largest of companies and institutions, the now ubiquitous computer is altering the ways we live, the ways we do business and the ways we learn.

To consider how our colleges and institutes can respond to these changes, the Committee on Computer-Based Education was formed. This, the final report of the Committee, contains a wide-ranging discussion of the many issues related to educational computing and presents several important recommendations.

A policy on educational computing must consider the following items:

1. Accessibility to computing power is the main issue.

2. The second major barrier to the widespread adoption of computers in college education in the short-term is the need for the training of a whole generation of faculty and administrators.

3. The goal must be to create a physical and intellectual environment within which students work comfortably with computers as intellectual tools of exploration and discovery.

4. The ways in which computers will be used in education are many and varied and most are yet to be determined. Because the computer is an intellectual tool in the learning and creative processes, the policy should be flexible and responsive and it should encourage the exploration of new ways in which computers can be employed and avoid becoming restrictive and deterministic.

The Committee recommends that:

1. The colleges and institutes accept the principle that the use of the computer as a tool is fundamental in college education;

2. The colleges and institutes consider the use of computing as an essential tool in every academic endeavour;

3. The colleges and institutes collaborate in setting common goals for computer applications;

4. A special effort be made to adapt this technology to provide an enhanced level of service to people who are in need of distance education solutions;

5. Targets be set for the provision of hardware and software within the colleges and institutes to achieve the goal of computing on demand;

6. The colleges and institutes establish multi-faceted programs designed to train faculty in the use of computer technology in their teaching;

7. A special effort be mounted to create a co-operative and positive atmosphere towards technological change among the faculty and other employees in the college system;

8. A central organization be assigned the responsibility for negotiating special software pricing and licensing agreements on behalf of the college system;

9. The policy be to encourage the growth of a British Columbia-based software industry to serve the emerging needs of our schools and colleges;

10. The government and the institutions collaborate on the preparation of a policy on the ownership of copyright of educational materials produced within the college system;

11. A wide range of contemporary hardware from the commercial marketplace be accepted for use in the college system and no attempt be made to impose a rigid set of standards for the acquisition of hardware;

12. Leadership and advice be provided to the colleges and institutes in the selection and implementation of suitable networking on each campus to provide for the growing need for communications in education;

13. The government and the institutions recognize the dynamic nature of educational technology and that they jointly provide for the ongoing monitoring of new developments as they emerge;

14. The responsibility to monitor changes in the technology and to advise the colleges and institutes of these changes as they occur be assigned to a central agency.

Each of the colleges and institutes should be invited to discuss the issues raised in this paper within its own constituency and to consider how the recommendations made herein might affect the present and future conduct of its programs.

The object of this debate should be the development of a clear statement of policy regarding the role of technology in college education and the creation of the means for implementing technological change into the college system in a sensible way on a continuing basis.

In view of the history of successful inter-institutional co-operation on a variety of issues, it is suggested that the colleges and institutes, in a joint venture with government, form an agency to undertake the central-agency tasks outlined in this report.

The Committee suggests that a centre should be established in each college or institute to act as a focal point for introducing the new technologies to that institution. The centres will be capable of demonstrating current educational technologies and of providing training to members of the college community in their use.

Special demonstration and development projects which build on existing strengths should be initiated in the college system. These centres of excellence will undertake work which will be of benefit to the entire system whether it be specialized courseware, experimental techniques or prototype applications.

A three-year plan for capital and operational spending on technological change should be prepared through a process of joint consultation between the college system and government.

Chapter 2

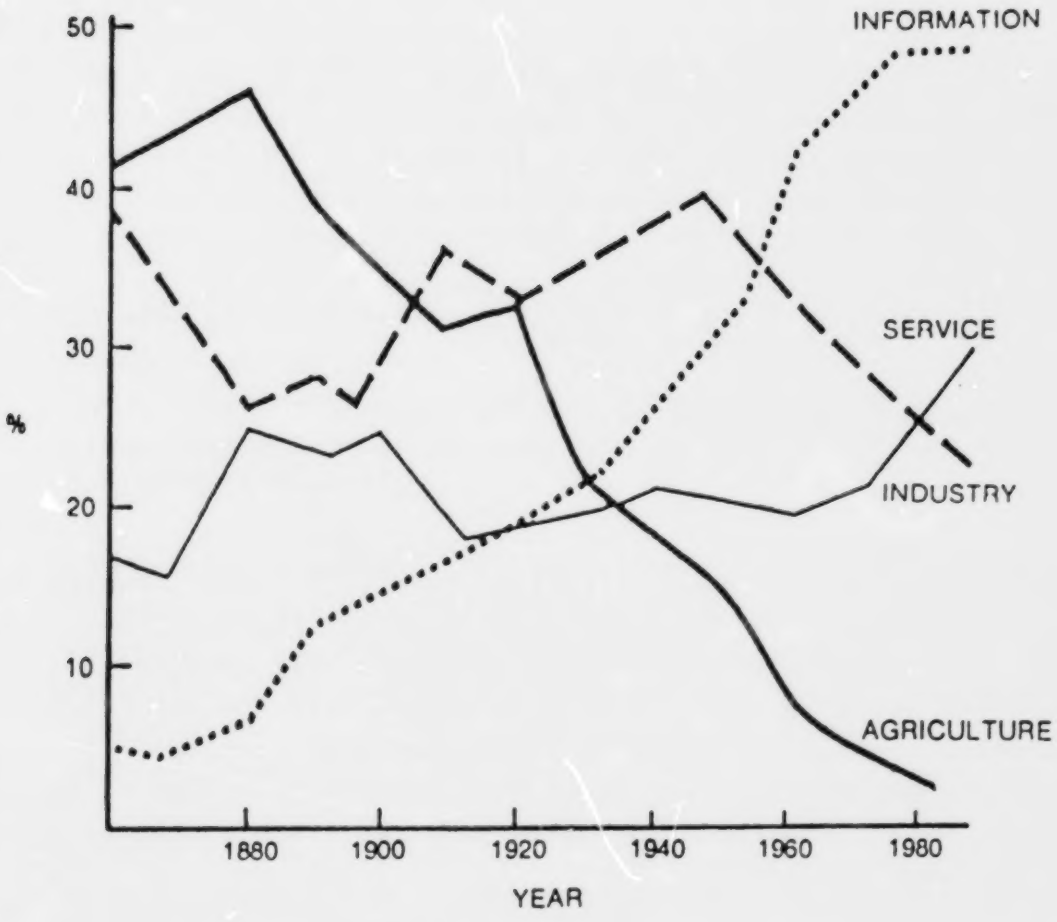
INTRODUCTION

> "A new civilization is emerging in our lives, and blind men everywhere are trying to suppress it. This new civilization brings with it new family styles; changed ways of working, loving, and living; a new economy; new political conflicts; and beyond all this an altered consciousness as well. Pieces of this new civilization exist today. Millions are already attuning their lives to the rhythms of tomorrow. Others, terrified of the future, are engaged in a desperate, futile flight into the past and are trying to restore the dying world that gave them birth.
>
> The dawn of this new civilization is the single most explosive fact of our lifetimes."
>
> - Alvin Toffler
> (Toffler, 1981, p.9)

Toffler called the new civilization "the third wave", Daniel Bell called it "the post-industrial economy", Naisbitt referred to it as "the information economy". Not wishing to join the semantic fray, Cohen and Shannon refer to the Canadian version simply as "the next Canadian economy". There is a widespread consensus that, by whatever name it be known, we are undergoing dramatic and irreversible changes in our ways of life.

This shift from agriculture and industry as the mainstays in our economic lives to service and information has been underway for many years but it was not until the '60s that we began to realize that the industrial era was coming to an end. (See figure on p.6) It is far from clear what the characteristics of the new era will be.

The Growth of Information Occupations
U.S. Work Force 1860-1980



Source: Porat, *The Information Economy*, Vol. 1, P. 121

"The computer revolution is the central dynamic propelling us into the new society." (Edgerton, 1984, p.1) In the same way that the machines of the Industrial Revolution were central to that age, computers, as information processing

machines, are key to the information society. However, because of the personalization of the information processing function, there is a significant difference:

> "The information machine has a unique characteristic: It is a democratizing instrument. It has a great levelling effect in making information available to people where they need it and can use it. This seems to be tremendously important, and I am not sure that we as a society yet understand what the total implications may be of this information capability."
>
> Louis Robinson
> (Robinson, 1984, p.12)

The democratizing features of information machines can only be realized if we have a society literate in their use. The same thing could have been said about the printing press and the mass distribution of books. And in the same way, the new information technologies will revolutionize education just as the invention of printing did 500 years ago, but the pace of change is much faster now.

To consider the implications of new information technologies on the college system in British Columbia and to initiate a process of discussion, debate and policy formulation, the British Columbia Ministry of Post-Secondary Education (then the Ministry of Education) appointed, in March 1986, a Committee on Computer-based Education with membership from among the colleges and institutes. The Committee was asked to prepare a discussion paper on the matter by June 30, 1986.

Terms of Reference

Issue:

Applications of computers for post-secondary educational purposes are increasing rapidly. The major issues involving CAI and CML, however, have not yet been identified and there is a lack of coordination in the development of CBE in the Post-Secondary system.

Background:

Computer-Assisted Instruction (CAI) and Computer Managed Learning (CML) are two areas that appear to be gaining momentum in the Post-Secondary sector. Hardware acquisition and software development (and purchase) is currently occuring at the institution level with little interaction with other institutions and virtually no direct input by the Ministry. Further, there are no provincial policies in regard to standards in equipment, software or courseware development.

As a result, the Post-Secondary system may face duplication of efforts, less than optimal patterns of expenditure, varying qualities of products and incompatability from one system to another.

The Committee on Computer-based Education will have as its mandate the task of identifying and examining the issues related to CBE in the Post-Secondary system.

Specific Terms of Reference:

- To identify the issues of CBE, both current and potential;

- To propose general guidelines for institutions in regard to equipment purchase, software purchase and software and course development;

- To involve many institutions in setting the direction of the Post-Secondary system with respect to instructional computer use;

- To examine possible roles for the Ministry of [Post-Secondary] Education in co-ordinating and facilitating the development and application of CBE in the system.

Committee Membership

Keith Bateman
Camosun College

Jim Baxter
Ministry of Post-Secondary Education

Terry Clement
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Iain Cooke
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Conduct of the Project

The Committee met once in each month from March to June to discuss the various issues and recommendations. To supplement this traditional form of meeting, the Committee was provided with an electronic message and computer conferencing service by the University of British Columbia. By this means the members of the Committee were able to participate almost on a day-to-day basis in the preparation of this report as drafts of the various chapters were distributed to each member for comment. As an additional benefit, Committee members were able to experience at first hand some of the advantages of electronic telecommunications through computers and, as a consequence, each member has become a staunch supporter of any and all efforts to improve the technology of computer communications!

As background to the project, Doug Schweitzer attended the annual conference of the Educational Computing Organization of Ontario sponsored by the Ontario Institute for Studies in

Education in Toronto at the beginning of May followed by the Fifth Canadian Symposium on Instructional Technology sponsored by the National Research Council in Ottawa. As well, he, Bruce Fraser, Chairman of the Committee, and several members attended The World Congress on Education and Technology organized by the B.C. School Trustees Association in Vancouver at the end of May. Other conferences attended by members of the Committee in their college roles were the American Educational Research Association Conference in San Francisco in May and the Distance Education Conference, co-hosted by the Open Learning Institute and the Knowledge Network in Vancouver at the end of May.

To supplement the literature review, the conferences and the discussions, a special two-day meeting of the Committee was hosted at Malaspina College on May 8 and 9. Presentations by North Island College, Camosun College, Cariboo College, and British Columbia Institute of Technology informed all members of the Committee of work in CBE underway at each of these institutions. Highlights of the workshop were presentations by two special guests: Jean Dexheimer, Assistant Vice-President of Computing and Information Services at Carnegie Mellon University in Pittsburg and Dr. Michael Szabo, Manager, Instructional Systems Group, and Professor of Educational Psychology at the University of Alberta in Edmonton. The information provided by these two speakers, both with extensive experience in using computers in education, was most enlightening and helpful to the Committee.

Chapter 3

COMPUTER-BASED EDUCATION

Computers in Education

Computers have been present in education since their very beginnings. Originally developed as calculating machines, hence the name "computer", the first use of computers in education was in that capacity. Subsequently, the computer began to serve as a data storage and retrieval device and it soon became an essential tool in the administration of educational institutions. For many years these two roles essentially defined the use of computers in education.

Recently the information-processing capabilities of the computer have promoted the spread of computing into areas other than the quantitative disciplines. The advent of low-cost computing brought about by the introduction of microcomputers in the mid-seventies has accelerated the migration of the computer into all aspects of education.

There are at least five distinct potential ways in which computers can be used in education (Balkovich et al, 1985):

1. Teaching and research in the sciences and engineering;

2. Financial management and record keeping in administration;

3. Productivity applications and office automation;

4. Electronic mail and other forms of computer communications; and

5. As an integral part of the instructional process.

Computer-based education can be broadly defined as the use of computers as tools in the pursuit of educational objectives. Computers can be used in a variety of applications for educational purposes. Some of the more popular are discussed in the following section.

Educational Applications

A very important theme is evident in the typical applications listed below, the emerging role of the computer as an extension of the teacher and as a tool for the student. Through the use of the computer, a teacher can more effectively communicate and illustrate complex ideas, give a student patient practice in applying learned concepts, even monitor his or her (the teacher's) own effectiveness and make adjustments for improvement. Many applications serve to free the teacher from the more mundane tasks of education and provide the opportunity to spend a higher quality time with the students, time that can be used to develop "less tangible, critical skills such as thinking, reasoning, and basic communications" (Naisbitt, 1984b, p.27).

In the hands of students, computers become a tool of intellectual exploration and discovery. Concepts can be examined and tested, with the teacher acting as a guide rather than a tutor. Vast amounts of information can be retrieved, analyzed, organized and, ultimately, translated into knowledge. The communications capabilities of the computer, whether in the creation of text and images or in the exchange of ideas and information with others next door or around the world, expand the horizons of our students in ways we never before dreamed possible.

The role of the computer is not to replace teachers but to free them to do what humans do best: to individualize and personalize the learning experience (Cowper et al, 1985). A teacher freed from routine work like testing, marking, and even information transfer has time for the more stimulating task of dealing with individual learning problems and the development of a critical thinking process in students. The computer also allows the student to obtain as much reinforcement as he or she requires without taking up valuable teacher time.

Word Processing

Encouraging students to use word processing facilities in the preparation of reports, essays and term papers has resulted in dramatic improvements in the quality of their written assignments. Papers done on word processing systems tend to have fewer spelling errors and to be more legible, and students are more apt to edit and revise their work, which results in a more professional final presentation (Dellow and Poole, 1984).

New software is appearing which is changing word processing into idea processing: memory-resident spelling checkers signal misspellings as they are typed; an electronic thesaurus can provide a choice of synonyms at the touch of a key; outline processors link text to multi-level outlines and permit the instant reorganization of the associated text by simply changing the outline; style analyzers and grammar checkers suggest improvements in writing and grammar; graphics editors permit easy illustration of ideas, sometimes in color; and page makeup software with laser printers place sophisticated publishing capabilities on the scholar's desktop.

Computation and Data Analysis

An abundance of application software, such as electronic spreadsheets, statistical packages and graphics programs, allows students to easily make use of the computer for computation and data analysis (Dellow and Poole, 1984).

Data and Information Management

Data Management programs give sophisticated electronic filing and retrieval capabilities to students. The ability to store and rapidly retrieve information is a vital asset in many educational situations (Dellow and Poole, 1984).

Simulation and Modeling

The use of computers to simulate real life events in both the social and physical sciences is an effective method of teaching. Phenomena that are too complex to be understood from mathematical formulations can frequently be simulated to aid the development of real, intuitive understanding (Dellow and Poole, 1984). A further benefit of simulation is the opportunity to pose a variety of "What if?" questions about the system (Balkovich et al, 1985). Often the use of simulations can save time and money as well as providing increased safety.

Drill and Practice

Computers excel at patiently aiding a student to learn skills through repetition. Since the work can be repeated indefinitely without adverse judgement of the student, the technique can be particularly effective with slow learners (Dellow and Poole, 1984).

Laboratory Applications

The microcomputer can readily be used as a universal laboratory instrument. It can generate signals, gather data, and display and analyse results. Providing meaningful laboratory experience for students is an expensive and frustrating process which might often be better accomplished by simulation on computer or by the use of a computer as a virtual laboratory (Balkovich et al, 1985).

Telecomputing

Increasingly, computers are being used for telecommunications on and off campuses. Through the use of messaging and conferencing systems, students can exchange communications directly with their instructors and with each other. Telecommunications puts groups of people together in a network by providing electronic bulletin boards and mail services that allow them to share information and ideas, to communicate about common interests without concern for geography or time schedules (EPIEgram, 1986; Peel et al, 1986a).

Distance Education

Computer communications can be particularly effective in distance education. Correspondence courses via mail make effective communication with teachers and other students difficult. The use of computers in distance education enables students to correspond easily with their teachers and also permits students to communicate with each other as well as providing a quick and efficient means of obtaining lesson material and instructions and submitting assignments (Collen et al, 1986a).

Information Services

Computer access to library catalogues and, in the near future, to electronic text enhances the services of the library and makes it more accessible. New services, such as personalized newspapers culled from news services and access to course catalogues and students' evaluation of courses, can be readily added (Balkovich et al, 1985).

Information Utilities

Hundreds of on-line databases provide immediate access to vast amounts of information in virtually every field. Currently, access to such databases is quite expensive but several developments are likely to reduce this cost in the future. The introduction of mass storage devices for microcomputers, such as CD-ROMs, will soon make it unnecessary to use on-line databases for retrieval of static information. The development of high capacity, high speed data networks using fiber optic technology could significantly reduce communication costs in the future.

Computer-Assisted Instruction

CAI is the use of the computer to teach a whole course, or to supplement a course with instruction on the computer. Unfortunately, CAI packages have tended to come in two types: questionable quality/low price, or excellent quality/outrageous price. Available courseware exists in nearly every subject field and ranges from relatively simple page-turning presentations to highly sophisticated, high quality interactive packages employing the latest in computer, video and graphics technology (Baldridge, et al, 1984).

To ease the problem of creating effective courseware, a wide variety of authoring languages and systems are

becoming available. Authoring languages provide great capability and flexibility but usually require the services of a competent programmer for the creation of course materials. Authoring systems, on the other hand, enable non-programmers to create quite good courseware by using menu-based software. NATAL is a Canadian-made authoring language, initially developed by the National Research Council, and now being widely used throughout the country. OMNISIM is an authoring system developed at the University of Alberta for creating PLATO courseware. PLATO is the world's most widely known computer-based learning system. Many other authoring languages and systems are available, offering a rich diversity of ways in which computer-based education materials can be produced by experts and novices alike.

Computer-Managed Learning

In CML the computer is used to aid instructors in the management of the educational process by providing facilities for designing curricula, courseware monitoring, test banking, test generation and marking, and record keeping (Collen at al, 1986b).

Electronic Blackboard

The use of a computer as an electronic blackboard enables the teacher to display previously stored information on large TV monitors in the classroom. Simulations and other demonstrations can be easily presented to the class. The technology exists to control video cassette recorders and videodisks by computer, and presentations can be easily enriched with audio-visual sequences (Balkovich et al, 1985).

College Computing Today

All colleges and institutes in British Columbia have computing facilities for administrative purposes and for teaching computing science. As well, all have acquired personal computers in varying quantities and make them available to students and faculty in laboratories and in common areas. Generally, there has been limited integration of computers into the curricula and the ratio of students to machines remains very high. Current uses tend to focus on productivity applications, such as word processing and electronic spreadsheets. Relatively little use is made of computers in a tutorial or CAI role at the present time although a number of promising activities are underway.

The colleges and institutes have historically worked co-operatively with one another in developing computing capabilities and educational programs. The British Columbia Computers in Education Committee has long served as a forum for articulating the educational uses of computers among the colleges. During the activities of this group the need for closer co-operation in operations and management became apparent and a loose federation of a dozen or so colleges and institutes was formed under the name of the Computer Centre Managers Group. The original purpose of this group was to negotiate better terms and prices for software support from Digital Equipment Corporation. Since then it has become a forum for discussing common operational and management problems, negotiating joint software licensing, making joint submissions for upgrading equipment, and arranging bulk purchases of software and hardware (Dunnett, 1986).

Most of the same institutions are connected to a common network for easy exchange of electronic messages and transfer of program and data files. Separate consortia have

been formed among various colleges to prepare and support administrative computer systems, such as the Student Record System and the Financial Record System.

North Island College, created as an open learning and distance education college, has developed an extensive network of microcomputers and terminals in the relatively remote communities it serves. More than half of the courses in computing science are CAI-based and delivered over the network to students throughout the region. Some business courses also make use of the computers. Plans call for increased development of courseware, using the NATAL authoring language, TENCORE and Concurrent Authoring System, for remote delivery and for the development of improved communications capabilities to serve a variety of college courses.

Cariboo College and the College of New Caledonia are using CML software on an experimental basis, and both report positive results (Collen et al, 1986a; Peel, 1986). As well, BCIT is successfully developing courseware using the TENCORE authoring system. Cariboo College and Selkirk College are using a computer conferencing program, called CONFER, developed at Camosun College, for the delivery of course materials to students.

Along with its purchase of a CAD/CAM system, Camosun College negotiated the use of Control Data's PLATO system for a two-year trial period. Some of its courseware is being used to supplement mathematics, computing and basic skills courses within the College. The TUTOR authoring language and the OMNISIM authoring system are both being used by college instructors to create their own lessons in subjects ranging from carpentry to nursing.

British Columbia, because of its geography and widely-dispersed population outside of the lower mainland, has found it necessary to develop an extensive distance education system. The Knowledge Network, the Open Learning Institute and the University Consortium, outgrowths of this need for providing post-secondary education in remote areas, have all contributed to the province's world-wide recognition in this field. Computer communications and CAI are beginning to play a significant role in distance education in the province.

For the next several years at least, the role of educational computing in B.C.'s college system is expected to be in transition. As computing becomes more common throughout the educational programs of the institutions, attendance at college will provide the first computing experience for many students (Peel et al, 1986b). For the most part, computing courses will concentrate on basic literacy, with a few courses providing for more advanced uses of the computer. As faculty become more familiar with computing and as more resources become available, the colleges and institutes will experience a more sophisticated use of computers in their educational programs (Maydan et al, 1986).

The presence of computers in schools is growing exponentially all across Canada and we will soon see experienced users appearing in community colleges. When that begins to happen another major shift will take place in the nature of college computing. Colleges will no longer need to focus mainly on basic computer literacy but will be able to assume a minimum level of capability in their students and will redirect their computing efforts accordingly.

Computer-Aided Instruction - Costs And Effects

One of the more exciting uses of computer technology in education is that of tutor. Much of the educational process involves the transfer of information and the repeated application of knowledge to the solution of practice problems. The role of the computer as a patient, non-judgemental tutor, delivering information and practice to students at their own pace and tailored or customized to their own needs, has long caught the eye of educators. The prospect of providing quality instruction to increasing numbers of students has excited administrators faced with educating more people to ever-increasing levels with limited resources.

What do we know about CAI? How does it compare to traditional methods of learning? Is it effective? Does it displace or replace teachers? What does it cost? How do students respond to this method of learning?

Research on the effectiveness of CAI is encouraging but far from complete. Baldridge et al report on a 1983 review of 301 studies analyzing CAI effectiveness in grades 6 through 12 (Baldridge et al, 1984). Due to methodological flaws, the reviewers were forced to reject 250 studies. However, the remaining 51 studies shared many conclusions. They indicated that CAI does increase student achievement, that it significantly reduces the time needed for mastery, and that it increases positive attitudes to both the computer and the subject matter. Other studies confirm these findings (Baldridge et al, 1984; Cooke, 1986; Hawley, 1986). The concensus is that CAI reduces learning time by 20 to 50 percent and is at least as effective as any other means of learning (Szabo and Bagnall, 1986). In studies which report significant cost savings arising from the use of CAI in training, it is usually this time factor which produces the savings. Where there is no direct cost assigned to the students' time, savings are minimal.

During a visit by the author to the Career Start program at Vancouver Vocational Institute, students studying highschool equivalency on a PLATO system responded enthusiastically when asked how they felt about taking courses by computer. They liked the opportunity to work at their own pace, to review difficult material repeatedly without judgement, and, particularily, to complete their studies to Grade 12 in only a month or two after dropping out of highschool in Grade 9 or 10.

One point which needs emphasis is that the effect of computers in education is just as diverse as the effects of textbooks, videos and slide presentations. Students do not learn from the computer any more than they learn from the slide projector. It is the instructional content and the design of the software which promotes learning (Baldridge et al, 1984).

There are many advantages to CAI (Baldridge et al, 1984, p.124):

"1. CAI provides individualized instruction through custom self-tailored learning paths.

2. CAI is self-paced and available 24 hours a day, seven days a week.

3. Immediate feedback is given to the learner.

4. Mistakes become a learning rather than a punishing experience.

5. A nonthreatening environment is created wherein the student can feel free to access exactly what is needed. It is less intimidating to ask a computer time-consuming details than to ask the teacher. With CAI, students can take their time rather than the time of others.

6. Simulation is possible. Experimenting with alternatives aids total comprehension.

7. Audio interaction is possible with speech synthesis.

8. Hours of grading and scoring can be eliminated.

9. Courseware can build in a test validity study for use in course improvement."

The cost of developing, producing and delivering CAI courseware can be staggering. Probably the best known CAI system is PLATO. Originally developed in 1962 at the University of Illinois it was taken over by Control Data Corporation which had very successfully used it to train its own personnel. In the subsequent 20 years, more than 12,000 hours of courseware has been developed for the system. Control Data has invested more than a billion dollars in making it one of the world's most comprehensive instructional systems (Baldridge et al, 1984). Consequently, the PLATO system lease is often considered too expensive, particularily if it is added on top of existing personnel costs. However, if more students can be taught with the same personnel costs, the system can be much more attractive. Control Data is in the process of moving some of its software onto IBM PC systems and the resulting price may be much more palatable.

Production of computer courses costs from US$50,000 to US$100,000 per course and can take from three to five years to complete. Estimates range as high as 250 to 300 hours of programming for each hour of computer instruction (Baldridge et al, 1984). The advent of sophisticated authoring systems is reducing the development ratio to something in the order of 40 to 80 hours for each hour of courseware (Szabo and Bagnall, 1986). It is anticipated that the price per course will fall rapidly as the volume of demand rises.

Perhaps the most important aspect of costs is that of general trends. For the past several years traditional instructional costs have been rising at an annual rate of 13 percent while the costs of producing CAI materials have been decreasing at an annual rate of 5 percent (Norris, 1977). It may only be a matter of time until the costs of CAI are competitive with the costs of conventional instruction (Szabo, 1986b).

Certainly we have not heard the final word on the cost or the effectiveness of CAI in education. However, it is clear that there is a growing interest in the use of the technology in our college system and efforts will be required to familiarize college faculty with CAI so that it may be evaluated and implemented effectively.

Chapter 4

NEW DIRECTIONS IN EDUCATIONAL COMPUTING

The Mind Tool

> "One of the most important themes in the history of civilization is our ever-increasing use of tools to shape and control the world around us. These tools range from the simple hammer and saw of the carpenter to all the complex machines of our modern civilization. We use tools to extend the power of our muscles, the speed and dexterity of our fingers, and the keenness of our sight, hearing, taste, smell, and touch. Tools allow us to engage in activities to which our unaided bodies are totally unsuited, such as travelling through the air, in space, or underwater.
>
> Until recently, almost all tools served to extend the powers of our bodies rather than those of our minds. Such mind tools as there were fell into two categories: devices for doing arithmetic, such as the adding machine and the slide rule, and tools for preserving and communicating ideas, such as the technology of writing and printing. In the last ten years, however, a powerful, general purpose mind tool, the electronic computer, has become widely available. In almost any department store, we can now buy a machine that will not only do our arithmetic but help us think, write, learn, keep records, and retrieve information."
>
> - Neill Graham
> (Graham, 1986, p.4)

In the introduction to his book, "The Mind Tool," Graham effectively captures the changing ways computers are perceived in today's society. In their brief 40-year history, computers have undergone a metamorphosis unparalleled in any other technology. From the enormous and expensive calculating machines of the '40's and '50's have arisen the fast, portable, ubiquitous, and inexpensive computing devices of

today. Computers are now used for so many purposes other than computation that the name "computer" is no longer an adequate descriptor. Once available to only the most powerful and wealthy corporations and institutions, today's microcomputer is a personal problem-solving tool available to nearly everyone.

The role of computers in education has undergone similar dramatic changes and we can only guess at their future roles. In this chapter we will briefly review several projects which are underway at a few of the leading universities in North America and discuss a number of changes taking place in computer-related technologies in an effort to give the reader some flavour for the directions in which future educational computing may be taking. We make no claim to comprehensiveness nor is it our intent to provide a balanced view; rather we offer here a sampler of those projects and developments which have crossed our path during the course of the preparation of this report.

Project Athena

In May of 1983, Massachusetts Institute of Technology announced the start of Project Athena, an experiment to explore the potential uses of advanced computer technology in the university curriculum. A joint venture, involving MIT, Digital Equipment Corporation, IBM Corporation and other corporate sponsors, the project will, over its 5-year lifetime, invest over US$70 million in hardware, software, equipment maintenance, operations, and staff (Balkovich et al, 1985). About 2000 high-performance graphics work stations will have been installed in a university-wide network. Approximately 10 million dollars will be made available to faculty members of the university for the creation of new software to be used in MIT's own curriculum.

An explicit assumption of the project is that if computing is to become an integral part of education, it must be treated as a utility. Sufficient computing power must be available so that a user can work with computationally intensive applications without being aware of the presence of other users.

The system is a series of local area networks of both public and private workstations interconnected on a high-speed backbone network. The advanced technology work-station has an internal memory from 1 to 16 megabytes, a high-performance processor capable of executing at least 1 million instructions per second, a high bandwidth, bit mapped display for high-quality interactive graphics, and an "open" design that can be extended to include peripherals such as keyboards, sound-generation devices, video input/output, data acquisition and control devices. The operating system is UNIX.

Project Andrew

Carnegie Mellon University has recently announced "Andrew" software which provides a common user interface that adapts powerful desktop computers to the specific needs of higher education. Based on 4.2 BSD UNIX, Andrew will make education software as portable as textbooks by allowing the same programs to be used on computers from different manufacturers.

Developed under a 5-year, US$35 million contract with IBM, Andrew, in addition to allowing programs to run on different computers, has other significant features as well. It can manage a campus network of 7,000 or more terminals, allowing easy sharing of files and peripherals as well as making the services of large main frame computers available to every

terminal. It has an integral authoring language which allows faculty to prepare educational courseware employing the same commands and format used for all other functions. Graphics programs can be easily drawn on the screen from which the system will prepare the necessary code. It incorporates a word processing program and provides electronic mail and bulletin boards.

To run Andrew, a work station must be able to process at least 1 million instructions per second, have a high resolution display with at least 500,000 pixels on a screen at least 10 x 12.5 inches, have at least 1.5 megabytes of internal memory, have "virtual memory"--the ability to use high-speed disk storage to extend internal memory--and either be connected to a high-speed network or have a local hard disk that can hold at least 30 megabytes of information.

Scholar's Workstations

In mid-1983, Brown University began an ambitious, 10-year project costing some US$50 million to "study, evaluate, design, and mould the appropriate information technologies for a 'wired university'" (Shipp et al, 1983). To coordinate the research, development and deployment of these technologies, Brown created the Institute for Research and Information and Scholarship (IRIS). By the end of this decade, Brown plans to install a heirarchical network of some 10,000 "scholar's workstations".

All workstations will have high-resolution graphics and a mouse-controlled iconographic user interface. The minimum level workstation will contain 0.5 megabytes of internal memory, at least 5 megabytes of local disk storage, and will

be capable of processing speeds of at least 500,000 instructions per second. A medium level workstation will have at least 1 megabyte of internal memory, 10 megabytes of local disk storage, and a processor speed of 1 million instructions per second. All workstations will include a video disk interface and connections to a heirarchical, distributed network. The user interface will use icons and pop-up menus like the Apple Lisa or the Xerox Star systems. The workstation will provide access to a wide variety of scholarly tools and information and communication services. It will be an indispensable tool for the sharing of knowledge. It will be the scholar's desk, files, references, and correspondence with others, and it will be a growing set of tools that form the electronic study.

One of the cornerstones of the scholar's workstation is hypertext or non-sequential writing. Hypertext permits an author to construct a document which has within it branch points or links to other documents, local or remote. Rather than using footnotes to reference original sources, links can be created to take the reader directly to the original source, and the relevant text of the referenced document can be displayed in a separate window on the same screen. In the same way, readers can annotate documents and leave comments, questions, and corrections.

The logical extension to hypertext is hypermedia. In ways similar to hypertext, an author may link a variety of media--artwork, photographs, video, voice and sound, high-resolution graphics, music--to form an electronic document that engages all the senses.

Project Aries

An experiment underway at the University of Waterloo is designed to enable students to use powerful portable microcomputers, both on and off campus, in the pursuit of their educational objectives. Beginning with a grant of 310 laptop portables from Hewlett Packard in July 1985, the project expects to be supporting 1,200 machines by the fall of 1986. The project is building netorks and software so that students can have access to extensive software and data, high-speed and high-quality printers, and centralized personal file storage. The primary function of the network will be to allow students to "fill" the computer with software or data and to "dump" their finished work onto printers or plotters or into permanent mass storage.

For computing to become a universal intellectual tool which aids all our activities, it must be readily available at all times in a manner similar to a book, calculator, or pencil. The advent of truly powerful portable computers which can be conveniently carried anywhere will move us rapidly towards the ideal of computing on demand.

The project anticipates that students will soon be able to carry a fully functional laptop portable computer which will (Cowan et al, 1986, p.2):

1. be light-weight,

2. operate from solar cells,

3. be as compact as our regular-size 3-ring binder,

4. have at least 500,000 bytes of memory,

5. be able to store and retrieve all software and data using a wireless network, and

6. cost less than $2,000.

Interactive Video

Using optical storage technology, as many as 54,000 video images can be stored on one side of a 12 inch videodisk. This represents about 30 minutes of linear viewing. However, with videodisks, any of the 54,000 frames can be accessed directly like a song on a long-playing record. Finding a frame or the beginning of a particular sequence on a video tape can be a painfully long process as the tape is wound forward or backward to the desired location. With videodisk the process is essentially instantaneous.

When this high-speed, random access capability of retrieving images on videodisk is combined with techniques of computer-aided instruction the result is interactive video, one of the most exciting of the new educational technologies. An effective interactive training program will pretest the user to determine the appropriate level of subject complexity and retrieve suitable material from the videodisk. As the student responds to the training program, it will further guide the user along a path reflecting his most immediate information needs. Based on the responses, the student may be returned to review remedial material, branched to higher or lower levels of complexity, or moved quickly ahead to new information resulting in mastery learning at a rate which is best for each individual (Baldridge et al, 1984).

At present, the cost of producing interactive video courseware is still very high. As a result, use of the technology

is largely restricted to industrial training applications where the cost of students' time is a major consideration in any cost-benefit analysis.

One of the more interesting developments anticipated in this technology will be recordable videodisks that will allow updating of information and thus remove the last major drawback to disks. The trend toward miniaturization, higher capacities and lower prices is also expected to continue.

Optical Storage

Since the introduction in 1978 of 12 inch laserdisks as commercial products for the storage of television programs, the technology has held the promise of making inexpensive mass-storage available for small computers. In 1983, digital audiodisks were introduced in a 12-centimetre (4.72 inch) moulded plastic disk format. These disks, known as compact disks (CDs), store up to 74 minutes of very-high-quality audio program on a single surface. They are a miniaturized version of the laserdisks. In the brief three years since their introduction, CD player prices have dropped by a factor of 5 and the number of CD titles has risen to nearly 10 percent of that of conventional LP's (Laub, 1986).

The success of audio CDs prompted the introduction of CD-ROMs for the distribution of large, permanent databases. The acronym, ROM, means "read only memory". These disks, like records, can be used only for the retrieval of information and cannot be used for recording. Each CD-ROM can store about 550 megabytes of data or about 500 conventional books.

With an automatic changer, like a "jukebox", a virtually unlimited supply of CD-ROMs can be made available to a computer system. This conjures up an image of having an entire library available on-line to even the smallest microcomputer.

The entire 20-volume set of the Grolier Encyclopedia and an index, which takes up as much room as the encyclopedia itself, together occupy less than 20 percent of the space available on a CD-ROM.

New developments in this technology are expected to make read-write disks available during the next two years or so. Disks to which information can be written one time only are now available. It is also expected that storage capacities will increase tenfold over current disk technology (Laub, 1986).

Optical storage technology seems poised to revolutionize the business of education. Large catalogues, reference works and databases are now becoming available on optical storage devices and image databases are being produced by such notables as the Smithsonian Institute, the National Gallery of Art and the National Geographic Society. Full text publishing, such as the Grolier Encyclopedia and newspaper data, is just beginning and is expected to grow rapidly (Desmarais, 1986). Once mastered, a CD-ROM can be produced for about five dollars.

The Electronic University

Traditionally the only alternative to attending a college or a university to take classes has been to enrol in correspondence courses. Taking courses by correspondence through the mail is a slow, cumbersome way to learn and it eliminates a

very vital part of the education process--contact with the instructor and other students.

The Electronic University, founded in 1983 by TeleLearning Systems, Inc. of San Francisco, provides another alternative to taking courses. Through telecommunications, students can interact with the instructor, wherever he or she might be, and with other students taking the course. Instructions and assignments are delivered electronically and students submit their "homework" in the same way. Correspondence with the instructor is handled via electronic mail and students can engage in collective discussions with other students via computer conferencing systems (Osgood, 1986).

The Electronic University offers courses and degrees from regular, accredited institutions. That is, it does not offer courses or degrees itself, but only provides an alternative medium for colleges and universities around the continent to make their services available to a broader range of students electronically. About 27,000 students were enrolled in the Electronic University as of early summer 1986.

Artificial Intelligence

The greatest potential use of computers yet lies in the future. Perhaps it is the field presently called "artificial intelligence" (AI). AI is a branch of computing science which is attempting to program computers to perform tasks which, if done by human beings, would be said to require intelligence. An "intelligent" computer would be able to accept commands given orally and could respond to questions rather than simply follow detailed instructions. Such a computer would understand the information being processed and could serve as a teacher, consultant, reporter, accountant, investment advisor and secretary (Graham, 1986).

The field of AI can be divided into three broad areas (Wilson and Welsh, 1986):

1. Robotics: Equipped with visual and tactile sensors and programs, smart robots can perceive, analyze and make decisions as they respond to changes in their environment.

2. Natural language processing: Machines will have to be able to communicate in natural languages such as English if the majority of people are to get the most out of computers.

3. Expert systems: Computer programs, called expert systems or knowledge-based systems, can diagnose and solve problems in a narrow, technical domain. Expert systems now exist in medicine, business and industry.

Within the last two years, software products for building knowledge-based systems on personal computers have become available. For the first time tools exist for creating such systems without special programming expertise in the languages of artificial intelligence (for example, LISP and PROLOG). This development opens the door on a new type of computing, symbolic processing, which is likely to change the ways in which we think of computers and the tasks they can perform. We now have the potential to address some educational problems in new ways and to solve some educational problems which are currently unsolvable (Wilson and Welsh, 1986).

The Changing Face of Technology

In this chapter we have attempted, through a series of vignettes, to provide the reader with some sense of the way

in which present technology is moving to reshape education as we know it. However, technology is very dynamic and we can present here only a snapshot of current trends. Policy based on this static analysis will run the risk of being outdated almost as soon as it can be implemented. Developments we haven't even mentioned, such as the voice writer (Kurzweil, 1986), fiber optics, cellular phones, wireless modems, satellite communications, mass storage, to name only a few, may have a major effect on the technology of education within the next few years. Clearly, new directions in technology need to be monitored on a continuing basis and policy must be adjusted to reflect these changes. The creation of a literate, motivated and informed constituency in education is an important priority if we want to continue to provide our citizens with the education and training they need to cope with an ever-changing society.

Chapter 5

A POLICY ON EDUCATIONAL COMPUTING FOR THE 1990'S

The Universality of Computing

Predicting the future is a very uncertain business, particularly with respect to technology. However, certain underlying trends are evident. One is the growing universality of computing. "Computer technology is to the information age what mechanization was to the industrial revolution" (Naisbitt, 1984a, p.22).

According to Baldridge et al, (1984, p.2):

> "...every person will probably directly operate a computer within ten to fifteen years."
>
> "Every person will use a computer almost every single day."
>
> "By 1995 every home in the United States, with a few rare exceptions, will have some type of home computer."

They go on to make several guesses about the future of the technology (p.3):

> "Guess one: Truly powerful computers will be developed to fit in your coat pocket and go to work with you.
>
> Guess two: The primitive "electronic mail" links of today will be as sophisticated as your telephone within this decade.
>
> Guess three: Massive research and information librairies will be at the fingertips of every citizen in the country within the decade.

> Guess four: By the end of the decade, every child in the United States will be computer literate at some minimal level by the time he or she is eight years old.
>
> Guess five: By 1995 at least 50 percent of the jobs in the United States will require an active working knowledge of computers.
>
> Guess six: In 1995 almost every course in every college and university will use computers to some extent."

The price of computing power has been dropping steadily for the past 30 years at a compound annual rate of 25 percent and this trend is expected to continue at least for the next 10 years (McCredie, 1983). This means that a sophisticated microcomputer costing $10,000 today will cost less than $600 in ten years time. By 1990 the popular IBM PC class of microcomputer will cost less than $1,000.

Computers are being integrated into the public and high school systems in North America at an astounding rate. Between 1983 and 1985 the ratio of students to computers in U.S. schools dropped from 200 to 1 to 40 to 1 (Becker, 1986). In 1981 there were 265 computers in Alberta schools. By 1986 that number has jumped to more than 25,000 and the ratio has declined to 20 students to 1 computer (Petruk, 1986). Growth to a one-to-one ratio in leading provinces in Canada by the end of this decade is not an unreasonable possibility.

Several leading universities across North America have made or will soon make a microcomputer available to every student on campus.

The Challenge To Education

There is a convergence in these trends which will have an immense impact on education. McCredie (1986, p.1) states it well:

> "Higher education in this decade will be rocked by waves of change caused by the converging technologies of computing, high speed local and satellite digital communication, video disc and other large-capacity information-storage devices, graphics, two-way cable systems, and artificial intelligence applications. The information-processing challenges and opportunities presented by these changes are profound, particularly for higher education where most institutions are unprepared to deal with them effectively."

The challenge to education in British Columbia is not **whether** these technologies will be introduced into the educational process, but **when** and **how**. We can ill afford the consequences of being a "have not" province in the post-industrial age.

Meeting this challenge will require a concentrated and sustained joint effort by the many partners in education: the province, with responsibilities for funding and for setting general educational policy; the colleges, institutes, schools and universities, which develop and implement the educational programs; the employers who look to the educational system for the basic education and training needed for tomorrow's workforce; and, finally, the students, parents, teachers, and workers who want an education system of which to be proud and which will improve their lives in so many different ways. It is only through the preparation of a well educated population, conversant with the use of these technologies, that we can hope to take our rightful place in the new economy.

To enfranchise our students and teachers in the use of computer technology we must create an environment in which computers are readily available and easily used in the pursuit of educational objectives of all kinds. It means that hardware and software must be acquired or developed; that support must be provided to those introducing the technologies; that educational objectives be reviewed, revised and, often, replaced; and that educational methodologies be altered. In short, the whole business of education may be changed.

The challenge to education is to encourage and develop the potentiating features of the new technologies and to empower the student to be more responsible for his own learning. One of the characteristics which distinguishes current technology from other educational technologies is that it is a fundamental shift from tools for teachers to tools for students (Grubb, 1986). Ultimately it will be students who define the uses to which the computer will be put in education.

> "The goal is to make it possible for the teachers to teach less and the learners to learn more."
>
> - Sir Eric Lord Ashby

Towards A Policy for Educational Technology

Our educational methodology tends to reflect the nature of our economic activity. Prior to the industrial revolution, when artisans and tradesmen plied their trades singly and in small groups in a cottage industry environment, our education system was based on similar concepts. The growth of the huge, centralized factories of the industrial age prompted a parallel development in centralized, factory-based education. Individualization and customization made

possible by the new technologies will extend into education as well, driven by the need for more, better and continuing education, and supported by increasingly capable hardware and software (Cetron, 1985).

New policies are required to guide the changes necessary to adequately educate our citizens for the 21st century and to capitalize on the capabilities of the new technologies in the process. It is important that a high priority be given to the early consideration of new policies; the college graduates of the year 2000 are now attending elementary school.

Development of policy must consider the following items:

1. **Accessibility to computing power is the main issue.**

In the short term, access to computing will be primarily dependent upon access to hardware. An educational environment in which students (and teachers) line up to use a pencil and paper or have to reserve time a week ahead to use a calculator would be totally unacceptable today. Similarly, computing cannot be fully integrated into the educational process until it is available on demand to both students and teachers.

Even simple, inexpensive machines operating relatively unsophisticated software have been useful in introducing people to the technology of computing. Once the initial unfamiliarity is bridged, there can be a rapid growth in the acceptance of the technology into daily activities and a parallel growth in the demand for more and better software.

The continuing decline in price for a given minimum level of computing capability will soon make it feasible for students to supply their own computers. However, for the next few

years the computing experience of most students will be on hardware supplied by the colleges. The nature of the computing services provided by the colleges will likely continue to change over the years to keep providing equipment with capabilities not yet affordable to students and to provide more support services (networking and communications, information bases, etc.)

Over the long term, the most important policy issues to be addressed are software and curriculum related.

The central focus will quickly switch from a concern about hardware to software. The market for educational software is still in its embryonic stages and much of the software that does exist is unsatisfactory for one reason or another. Where courseware evaluation and reporting is performed by a public agency, as much as 95 percent is deemed unsuitable (Travers, 1986). A wide selection of quality software is needed and the policy should encourage its development and distribution.

As teachers and students become more accustomed to the use of computer technology their needs for software will change. Where tutorial, application, and drill and practice software may now fill the needs, future demands will be for database access, electronic text, imagery and communications.

2. **The second major barrier to the widespread adoption of computers in college education in the short-term is the need for the training of a whole generation of faculty and administrators.**

Not only are in-service training programs required but ongoing technical support for the introduction of the technology into the classroom must be provided. Other adjustments will also be needed as the role of the teacher undergoes a

significant shift resulting from changes in the technologies and methodologies of education.

3. **The goal must be to create a physical and intellectual environment within which students work comfortably with computers as intellectual tools of exploration and discovery.**

Different approaches or levels are suggested in the ways in which computer, or information, technology is considered for introduction into different scholarly communities (McCredie, 1983):

Elective	Computers are interesting objects of study.
Literacy	Every student should know about computing.
Skill	Computing is a requisite skill like reading and writing.
Foundation	Computing is viewed as the key information processing technology which in turn is viewed as the fundamental process in learning.

Each of these levels can be appropriate within the college system. While the long term goal should be to move towards developing computing at the foundation level, it is likely that we will see it at various levels in different situations and at different times. Currently, most colleges treat computing as elective, and some are moving towards the literacy level in their programs. For the next few years it is expected that the role of computing in the colleges will very much be transitional as the use of the technology becomes more widespread. The technology is spreading rapidly throughout the school system and, within a few years, students entering college will already have acquired significant skills in the use of computers in learning. The policy on college computing will need to be flexible, recognizing

that the colleges will go through a succession of levels as their computing capabilities increase, and as the responsibilities for basic orientation and familiarity move into the school system.

4. **The ways in which computers will be used in education are many and varied and most are yet to be determined. Because the computer is an intellectual tool in the learning and creative processes, the policy should be flexible and responsive and it should encourage the exploration of new ways in which computers can be employed and avoid becoming restrictive and deterministic.**

In this chapter we have attempted to set the context or the "glue" which binds the policy. In the next chapter we will deal with many of the specific issues which will arise in the establishment of the policy.

Chapter 6

ISSUES AND RECOMMENDATIONS

Developing appropriate action and responses to matters related to technology in education in the context of a fast-moving stream of technological change and among a multitude of often contradictory forces will require a continuing and joint effort on the part of those institutions most directly concerned with the college system in British Columbia. The matter is of sufficient import and urgency that a process of committed and co-operative deliberations be initiated as soon as possible.

In this chapter we will identify the main issues which we feel will need to be addressed during the development of a policy on educational computing in the colleges and institutes. Our intention here is to provide some focus for the initial round of policy discussions; the subject is simply too dynamic to enable us to recommend a fixed policy statement for the next five or ten years. At best, the recommendations put forward here represent a shot at a moving target. Indeed, one of our strongest recommendations is for ongoing review of the policy in the face of the many, varied and shifting forces at work on both the technology and on education.

Not only is the technology changing quickly, the role played by the college system in this field is transitional. As the schools in British Columbia increase the degree of computer training and use in their programs, the students arriving at the colleges and institutes will become increasingly

sophisticated in their use of computers and their expectations will, consequently, be different. Therefore, policies which may be suitable for the next couple of years will soon need revision.

Curriculum

The first issue to be addressed in the development of a suitable policy is the degree to which the technology will be introduced into the curricula of the colleges and institutes. Travers (1986) has identified three central applications of computers in schools: learning ABOUT computers (literacy); learning THROUGH computers (CAI); and learning USING computers (as a tool). We consider all three applications to be appropriate but the emphasis should be on integrating the use of the computer as a tool in all parts of the college curriculum.

The Committee recommends that the colleges and institutes accept the principle that the use of the computer as a tool is fundamental in college education.

Furthermore, the Committee recommends that the colleges and institutes consider the use of computing as an essential tool in every academic endeavor.

To ensure that an adequate and consistent level of skills in the use of computers be available to all college students, the Committee recommends that colleges and institutes collaborate in setting common goals for computer applications.

Lifelong learning and frequent retraining are fast becoming a regular feature of our lives. The colleges and institutes are in an excellent position to serve the emerging adult learner but new methods and formats of delivery are

required. The computer can play a vital role in providing self-paced, individualized learning opportunities both on and off campus to supplement, and in some cases, replace more traditional delivery methods.

The Committee recommends that a special effort be made to adapt this technology to provide an enhanced level of service to people who are in need of distance education solutions.

Access

The single most important factor determining at what rate computer technology makes its way into the college system is access by faculty and students to computers and software. An hour or two per week in a lab or a class is inadequate. Computing must be available when needed.

The Committee recommends targets be set for the provision of hardware and software within the colleges and institutes to achieve the goal of computing on demand.

It will be an expensive undertaking to supply the hardware and software necessary to provide computing on demand. Close collaboration between the institutions and government in a process of systematic decision-making will be needed to solve problems of supply. A planned sequence of funding will be needed over a number of years, and innovative plans and programs will be required to achieve targets. It will be necessary to develop co-operative arrangements among government, colleges, students, faculty, manufacturers, and employers. Strategies currently being employed in various jurisdictions include:

1. Grants for the purchase of computer hardware and software for instructional laboratories.

2. Grants or loans to students for the purchase of their own computers.

3. Computers are made available to students upon registration and some cost recovery is achieved via an increase in tuition.

4. Grants of hardware from businesses (manufacturers as well as employers).

5. Favorable volume purchase arrangements are negotiated with hardware and software manufacturers and savings are passed on to students and faculty.

6. Assisted purchase plans are provided for faculty and students.

7. Computers are rented to faculty and students.

Training

Training faculty to use computer technology effectively in their teaching requires a considerable investment and must be part of the foundation upon which the policy is built. The temptation is usually to spend available funds on hardware and to ignore the human issues of training. Baldridge et al, (1984) suggest an appropriate ratio is 50:25:25; that is, 50 percent of available funds should be allocated to equipment; 25 percent to software, supplies, audio-visual support, and furnishings; and 25 percent to training.

Faculty are generally expected to keep themselves abreast of developments in their fields of specialty and provision is made for some professional development time and resources, all of which can be of assistance in solving these training needs. However, the magnitude and urgency of the current problem makes it necessary to develop a much more intensive program than that which could be mounted through current professional development initiatives.

Therefore, the Committee recommends that each college and institute establish a multi-faceted program designed to train faculty in the use of computer technology in their teaching.

The institutions themselves are in the best position to provide the required training and leadership. Funding, other resources and training standards are issues which must be addressed jointly between government and the colleges in association with faculty and other employees.

Elements of the program should include:

1. The creation of a training unit within each of the colleges and institutes to provide training sessions, advice and resources to faculty and staff at both introductory and advanced levels.

2. To make the technology most useful to faculty they should be provided with the means of making their current activities easier and more effective. For instance, word processing, intra-college communications, assembling and marking tests, recording and assessing student marks can be simplified and speeded up with appropriate software and hardware. Minimum training should make faculty operationally proficient in these areas.

3. Many faculty are eager to explore the new technologies, and simply the availability of hardware and software will be sufficient encouragement for them to teach themselves much of what they need to know to function at increased levels of proficiency. However, provision must be made for advanced training and for the encouragement of faculty to undertake this training. Key to this encouragement is the recognition that the training requires a substantial commitment of time and resources on the part of faculty.

Teaching

The wholesale introduction of computer technology into the college system over the next few years brings with it the potential for many changes in the manner in which educational services are delivered to college students. Self-paced learning packages, individualized training plans, remote access to learning systems will all interrupt traditional classroom-based instructional methods. These changes may understandably cause a fearful reaction among some faculty with a consequent reluctance to embrace the changes. The policy should endeavour to work co-operatively with faculty in the introduction of the new technologies and to foster a positive attitude among those who will ultimately bring many of the advantages of the changes to our students.

It is not clear what the net effect of CAI will be in the need for faculty. There does not yet exist an abundance of courseware for college-level courses. As the availability of courseware grows and as faculty use of instructional technologies spreads, there will be an increase in the productivity of our teaching staff. However, it is anticipated that there will be a growth in the demand for education and

training, and the technologies themselves will require people for the design, production, testing, distribution and delivery of instructional materials.

What is clear is that there will be many changes in the role of the college teacher. As the emphasis on traditional classroom instruction shifts to a more individualized and customized educational program based on the needs of each student, today's instructor may become more of a guide. Rather than delivering the same lecture to a large group of students, the teacher may spend much more time counselling individual students or developing critical thinking skills with small groups. New ways of thinking about the role of the teacher will be necessary; new measures of performance, based on output rather than input, will be needed; new methods of funding will have to be devised, methods which account for large numbers of students who seldom, if ever, actually appear on campus. Whatever the changes might be, the process of change will require accommodations we can only guess at now.

The Committee recommends that a special effort be mounted to create a co-operative and positive atmosphere towards technological change among the faculty and other employees in the college system.

Software

There are two classes of software of primary interest to education: productivity or applications software and educational courseware. Applications software is generally derived from the commercial marketplace and includes such familiar activities as word pocessing, electronic spreadsheets, data management, graphics, communications and so on.

It also includes specialty software for educators and administrators such as computer-managed learning (CML) packages. These applications can, and will, be used extensively within the academic environment.

The main issues confronting the colleges in this area are suitability and price. The selection of a package or packages from the hundreds available for various applications in the colleges can be a daunting task even for the initiated. The ready availability of guidelines and software evaluations for educational uses could be very helpful.

Manufacturers of productivity software frequently offer discounts ranging from 40 to 60 percent for educational use but generally require the purchase of one package for each machine upon which the package is to be run. The resulting cost for software is thus still very high and colleges find it very difficult to adhere to the requirements of this method of licensing. Site licenses would be much more practical in the college environment but it is difficult for any one institution to have the negotiating leverage necessary to obtain favorable pricing and licensing agreements.

The Committee recommends that a central organization be assigned the responsibility for negotiating special software pricing and licensing agreements on behalf of the college system.

Courseware

There is a rapidly growing repository of successful training and educational materials available on the market today although much of the courseware is inadequate and unsuitable.

However, a growing demand will likely force significant improvements in the quality of courseware being created.

The availability of quality courseware will become a very important issue. Leadership and encouragement will be required to stimulate the production of educational materials and the opportunity exists to aid the growth of the software industry in British Columbia by the implementation of appropriate policies. Ontario has taken a very aggressive posture in supporting the growth of information technologies in that province (Smith, 1986).

The production of quality courseware is not an easy or inexpensive matter. Estimates range from 40 to 300 manhours to produce a single hour of course material. The usual approach involves a team of three or four people, a content specialist, an instructional designer, a programmer, and sometimes a graphic artist, working together on a course. Authoring systems of increasing sophistication are beginning to appear which enable a much smaller team to produce good courseware.

While the quality and quantity of courseware will increase as the market grows, it is considered unlikely that the need will be met entirely by off-the-shelf products. Teaching is still a very idiosyncratic business and there will be a need for courseware which is produced or modified by individual teachers for their particular classes.

The Committee recommends that the policy be to encourage the growth of a British Columbia-based software industry to serve the emerging needs of our schools and colleges.

Building on existing strengths with co-operation among the colleges and institutes, a variety of methods can be employed, including the following:

1. Encourage the establishment of production centres within the college system equipped with suitable hardware and software and staffed with technical and resource people.

2. Promote the establishment of college programs to provide the training necessary for courseware production.

3. Contract with provincial software developers for the production of courseware for which there exists a widespread need.

4. Provide a clearinghouse for the exchange of information on the evaluation, distribution and sharing of courseware.

5. Provide an environment within which creative people already in the college system are encouraged to develop and use courseware.

Copyright

The issue of copyright of software/courseware produced with provincial funds needs to be addressed at an early date. The objective of the copyright policy should be to encourage the creation of quality software without creating a duplication of cost for the distribution of the software within provincial jurisdiction.

The Committee recommends that the government and the institutions collaborate on the preparation of a policy on the ownership of copyright of educational materials produced within the college system.

The issues of copyright are many and complex and the Committee feels that additional consideration must be given to this matter. The needs and interests of the several parties involved in the copyright issue suggest the careful exploration of a number of arrangements and the possible adoption of a flexible policy which can vary from situation to situation as circumstances dictate.

Hardware

The proliferation of the microcomputer since its introduction in the mid-seventies has been spectacular. Millions of units are operational on desktops around the world and they are appearing in schools, colleges and universities in vast numbers.

Like the computer industry generally, the microcomputer industry has been, and continues to be, a dynamic technology. Early microcomputers were small, slow and of limited capacity and, with hundreds of manufacturers in the marketplace, there existed little or no software compatibility among machines. In 1981 IBM entered the microcomputer marketplace with its PC-DOS machines and, within a few years, had virtually dominated the industry. Following IBM's lead, many manufacturers now produce compatibles and clones, all of which run MS-DOS, the non-proprietary version of PC-DOS. IBM's dominance is imposing a de facto standard on the industry and software producers are responding by announcing a great variety of software for MS-DOS systems. Apple and Radio Shack still maintain their own proprietary operating systems but Radio Shack has recently announced full MS-DOS compatibility with the Tandy 3000. Other manufacturers with proprietary operating systems (eg. Commodore Amiga, Atari 1040ST) also offer MS-DOS emulation as an option.

The microcomputer industry has moved in ten years from 8-bit single-user, single-tasking systems with limited memory (64k) and limited storage (160k) through 16-bit and into 32-bit processors with more than a megabyte of memory and with hundreds of megabytes of online disk storage. Some of the current systems are multi-user and multi-tasking. UNIX, developed by Bell Labs for minicomputers, is a very popular multi-user, multi-tasking operating system that is being moved down to many new micros and is frequently suggested as the standard operating system of the future.

The trend in hardware is towards ever faster, smaller and more capable machines. Several megabytes of internal memory in 32-bit multi-tasking, multi-user systems will soon become commonplace. Optical storage technology will provide gigabytes of online storage for microcomputers. High resolution (1024 by 1024 pixels) color graphic displays are becoming more affordable. Fibre optics are speeding communications well beyond today's technology. The above developments coupled with wireless communication (cellular telephone, satellite, infrared) technologies will make tomorrow's computer a high-speed, high-capacity, lightweight and portable information device. A new generation of processors may render the operating system question largely academic as they will be able to run several operating systems simultaneously (Machrone, 1986).

To a system which is still reeling from the horror of adopting the 1/2 inch reel-to-reel video tape as the educational standard, the matter of buying hardware in these uncharted waters is fraught with fears and dangers beyond the comprehension of mere mortals. The fear of policymakers is that, in the absence of standards, there will be a proliferation of incompatible or inadequate machines within the college system which will barely serve today's needs let alone those of tomorrow. Yet the establishment of standards carries

with it the risk of selecting the computer equivalent of the 1/2 inch video tape as well as the more significant risk of imposing a standard so rigid that many uniquely capable systems could not be permitted. A further problem is that the industry is changing so fast that the standards would be in danger of being obsolete before they could be promulgated.

The Committee recommends that a wide range of contemporary hardware from the commercial marketplace be accepted for use in the college system and that no attempt should be made to impose a rigid set of standards for the acquisition of hardware.

Rather, assistance and guidance should be made available to those colleges and institutes planning the purchase of equipment to ensure that it best meets their current needs and, at the same time, exhibits as much flexibility as possible for anticipated future developments.

While we concentrate most often on computer hardware, we recognize that emerging video technology is of growing interest in education. Image databases are appearing on the market which can be of immense aid to learning in many different fields. High-speed random access to still images and short film sequences can accentuate and accelerate the learning process. When integrated with computer technology, the potential uses of interactive videodisk in education are enormous. Colleges should carefully watch new developments in this field, and begin now to become familiar with the technology and to explore potential applications in all disciplines.

The current high level of interest and concern with microcomputers enables them to form an easily identifiable target for specific recommendations. Larger computers which share

resources will undoubtedly be of continuing importance in the foreseeable future. While uses of these larger computers have been in the minds of the Committee members throughout, the Committee does not make any specific recommendations concerning such machines. They simply represent another possible solution to the many problems of educational computing. Many of the recommendations in this paper apply equally well to large central computers, and the judgment as to which hardware configuration offers the best solution to a given problem should justly rest with those charged with making such decisions within the college system.

Networking

Connecting personal computers to each other and to host computers is of growing importance in modern educational computing. Sharing peripheral devices such as printers, plotters and storage devices, sharing software and data/information bases, and communicating among users will soon be essential functions in our colleges. Not only must this networking accommodate resident computers on the campus, it must increasingly provide remote service to students with their own machines and to other off-campus users. Nowhere is this of greater importance than in serving distance education needs.

There are three functional types of networks: local area networks; host/micro networks; and micro to information base networks (Baldridge et al, 1985). Local area networks connect groups of up to 30 micros sharing common printing and storage devices and software. They allow some advantages of sharing but maintain the important stand-alone features of microcomputing. Host/micro networks permit communications between micros and larger hosts to provide such useful

services as operating the host as a terminal, electronic mail and communications, access to the host's files and mass storage, and access to expensive peripherals. The micro can operate as a dumb terminal driving the host or as an intelligent device to exchange files with the host. Another form of host/micro network is the wide area network (WAN) which provides worldwide data communications via telephone and public data networks to give access to thousands of database and information services.

Networking microcomputers is still relatively new and expensive (upwards of $1,000) per machine) and the hardware/software is evolving quite rapidly. Wide area networks, while well developed in terms of coverage, are still slow, generally awkward to use, and very expensive. It is expected that fiber optic and satellite communications technology will have a major impact on the use of WANs in education.

The Committee recommends that leadership and advice be provided to the colleges and institutes in the selection and implementation of suitable networking on each campus to provide for the growing need for communications in education.

Monitoring Educational Technology

Presented in this chapter are a series of policy recommendations made in full recognition that the technology of education is emerging at such a rate that it defies encapsulation in a fixed policy.

The Committee recommends that the government and the institutions recognize the dynamic nature of educational technology and that they jointly provide for the ongoing monitoring of new developments as they emerge.

The strongest and most important recommendation of all is the last one:

The Committee recommends that the responsibility to monitor changes in the technology and to advise the colleges and institutes of these changes as they occur be assigned to a central agency.

Chapter 7

CONSIDERATIONS FOR IMPLEMENTATION

The Policy Debate

We have raised in this paper a number of issues which will become increasingly important as the brush of technological, economic and societal changes sweeps across our college system. To develop operational and policy responses to these issues will require a continuing and co-operative effort among government, colleges, educators, employers, students, and citizens. The first priority will be to initiate an ongoing dialogue among those most directly concerned with college education in British Columbia. This discussion paper should receive wide distribution among the colleges, educators, the public and the government with a view to stimulating an open debate about the nature and methodologies of college education in the future.

Each of the colleges and institutes should be invited to discuss the issues raised in this paper within its own constituency and to consider how the recommendations made herein might affect the present and future conduct of its programs. Of particular importance is the establishment within each institution, and among them co-operatively, of the means of maintaining the debate on an ongoing basis as the technology of education continues to develop and improve. It is expected that no program or curriculum will be left unaffected by the forces of technological change and it will become increasingly important to ensure that sensible and sensitive mechanisms are in place to accommodate these changes in a fashion which will ensure a continuing high quality in the education of our citizens.

The object of this debate should be the development of a clear statement of policy regarding the role of technology in college education and the creation of the means for implementing technological change into the colleges and institutes in a sensible way on a continuing basis.

A Central Agency

Several of the recommendations in this paper refer to the roles of a central, coordinating agency. Many of the issues addressed can better be solved by a central agency working on behalf of all the colleges and institutes. Matters such as the negotiation of favorable prices and terms for the supply of hardware and software, the evaluation of courseware, the sharing of information among institutions about technological developments and evaluations can best be facilitated by the existence of a central agency.

Several models for the formation of a central agency should be considered: a new agency could be established by and within the Ministry of Post-Secondary Education; one of the existing central agencies, such as the Open Learning Authority or the Provincial Education Media Centre, could be charged with the responsibility for these tasks; any one or more of several inter-college co-ordinating or articulation committees or bodies, such as British Columbia Computers in Education Committee or the Computer Centre Managers Group, could be asked to undertake some or all of the functions; or a new, co-operative, inter-college agency could be established in co-operation with government. The nature and magnitude of the work to be done requires, in the opinion of this Committee, the dedication of several full-time staff and sufficient resources as to preclude assigning the responsibilty to an existing committee. In view of the

history of successful inter-institutional co-operation on a variety of issues, it is suggested that the colleges and institutes, in a joint venture with government, form an agency to undertake the central-agency tasks outlined in this report. Specific responsibilities and level of resources would be established by the partners in the enterprise.

Production and Training Centres

The use of technology in education cannot happen without awareness, and awareness cannot happen without exposure. Introducing faculty, administrators and students to technology is absolutely essential if we are to realize the benefits from its incorporation into our educational system. We therefore feel that a centre should be established in each college or institute to act as a focal point for introducing the new technologies to that institution. The centres will be capable of demonstrating current educational technologies and of providing training to members of the college community in their use. Hardware, software and courseware resources will needed to support the operation of the centres, as will suitably trained technical and resource personnel. Each of the centres should have the resources to aid faculty to adapt the technology to individual teaching situations. Minimum facilities should be provided to enable production of some courseware.

Not all institutions are at the same level of development in the use of the new technologies. Some are more advanced than others and their fields of interest and expertise differ. Special demonstration and development projects which build on existing strengths should be initiated in the

college system. These centres of excellence will undertake work which will be of benefit to the entire system whether it be specialized courseware, experimental techniques or prototype applications.

As the production centres and centres for excellence begin to turn out courseware it should be distributed widely throughout the college system to supplement the growing inventory of materials from commercial sources. Individual employees should be encouraged to write quality software through the implementation of a suitable copyright policy and by a system of grants-in-aid.

Funding

Implementing technological change on the scale we expect to be necessary over the next few years can be a very costly enterprise, requiring innovative solutions and involving much co-operation among those with a vested interest in college education in the province. However, it should be noted that considerable amounts of money are currently being invested in technology in the college system. By developing a policy which addresses the issues raised in this discussion paper and by strengthening inter-institutional co-operation in these areas it is anticipated that significant advances can be made in maximizing the effects of funds already committed.

A three-year plan for capital and operational spending on technological change should be prepared through a process of joint consultation between the colleges and government. The plan should take into acc(nt current levels of spending and should set reasonable targets for implementation of the policies developed as a result of discussions arising from consideration of this paper. The plan will not remain

static for the three-year period; it will require ongoing modification as the technology of education evolves. Currently, computer technology undergoes generational changes on about a three-year cycle. This three-year horizon will enable the colleges and institutes to plan for the systematic implementation of technological improvements as a regular part of their developmental planning.

Conclusion

These are exiting times. New technologies are poised to change the face, not only of education, but of our society and our economy as well. The role of the teacher is about to be enhanced in ways we never dreamed of and students will enjoy individual freedoms and reponsibilities for their own educational destinies never before possible. Historically, in our society, technological changes have generally served to better our lives. However, these changes have often also carried with them undesirable side effects and the changes themselves are frequently accompanied by turmoil and unpleasant dislocations. The challenge to education in the remaining years of this century is to select the beneficial technological changes and to implement them in our educational systems with wisdom and sensitivity while minimizing their undesirable effects as we seek to prepare our citizens for better lives in the next century.

A difficult challenge, you say? You bet!

REFERENCES

"Towards a National Policy for a Computer-Assisted Learning Industry." **ACIT**, National Research Council, Ottawa, May 1984.

Baldridge, J. Victor, et al. **The Campus and the Microcomputer Revolution.** MacMillan Publishing Company, New York, 1984.

Balkovich, Ed, et al. "Computing in Higher Education: The Athena Experience." Reprinted from **Computer Magazine**, Los Alamitos, NM, 1985.

Becker, Henry. "Educational Scene: New Directions in Computing." A paper presented to the **Learning 2000 Symposium**, Ottawa, May 1986.

Cetron, Marvin J. **Schools of the Future.** McGraw-Hill, New York, 1985.

Collen, A.R., C.P. Peel and P.C. Maydan. "Implementation of Computer Networking in Higher Education." A paper presented at the **Distance Education Conference**, Vancouver, BC, May 1986a.

Collen, A.R., C.P. Peel and P.C. Maydan. "Computer Networks in Graduate and Undergraduate Psychology Programs: Models, Attitudes and Progress." A paper presented to the **Saybrook Institute National Meeting**, Belmont, CA, June 1986b.

Cooke, Iain. Personal Communication. Camosun College, Victoria, BC, June 1986.

Cowan, D.D., S. Fenton, J.W. Graham and T.M. Stephen. "Project ARIES: The University of Waterloo Portable Computing Project." Unpublished manuscript, Computer Science Department and Computer Systems Group, University of Waterloo, Waterloo, Ontario, April 1986.

Cowper, Don, et al. "Large Scale CAL in an Open Learning System: Twelve Month's Experience in Teaching Computer Science." North Island College, Courtenay, BC, 1985.

Dellow, Donald A. and Lawrence H. Poole, Ed. **New Directions for Community Colleges: Microcomputer Applications in Administration and Instruction.** Jossey-Bass, San Francisco, CA, 1984.

Desmarais, Norman. "Laser Libraries." **Byte Magazine,** Vol 11, No 5, May 1986.

Dunnett, Malcolm. Personal Interview. Malaspina College, Nanaimo, BC, June 1986.

Edgerton, Russell. "Entering the Information Society." **Current Issues in Higher Education. 1983/84 Series,** No 1, 1-2, 1984.

"Educational Telecomputing - Who's Doing It And How?" **EPIEgram,** Vol. 14e, No 3 & 4, Dec. 1985/Jan. 1986.

Graham, Neill. **The Mind Tool.** 4th Ed., West Publishing Company, St. Paul, 1986.

Grubb, Ralph. "Enhancing The Learning Process". A paper presented to the **World Congress on Education and Technology,** Vancouver, B.C., May 1986.

Hawley, David Ean. "The Cost, Effects, and Utility of CAI in an Elementary School in Canada." A paper presentedto the annual meeting of the **American Educational Research Association,** San Francisco, April 1986.

Kurzweil, Raymond. "The Technology of the Kurzweil Voice Writer." **Byte Magazine,** Vol 11, No 3, March 1986.

Laub, Leonard. "The Evolution of Mass Storage." **Byte Magazine,** Vol 11, No 5, May 1986.

Machrone, Bill. "The 80386: The More Things Change...." **PC Magazine,** Vol 5, No 12, June 24, 1986.

Maydan, P.C., A.R. Collen and C.P. Peel. "Attitudes of College Instructors Toward Integrating the Computer Into Educational Delivery." A paper presented at the **Instructional Skills Facilitators' Conference,** Naramata, BC, June 1986.

McCredie, John W., Ed. **Campus Computing Strategies.** Digital Press, Bedford, Mass., 1983.

Naisbitt, John. **Megatrends.** Warner Books, Inc., New York, 1984a.

Naisbitt, John. **The Year Ahead: 1985.** American Management Association, New York, 1984b.

Norris, W.C. "Via Technology to a New Era in Education." **Phi Delta Kappa.** Vol 58, No 2, 1977.

Osgood, Donna. "The Electronic University Network." **Byte Magazine**, Vol 11, No 3, March 1986.

Peel, C.P. "Computer Based Training Systems and Integrated Distance Education." A paper presented to the Committee on Computer-Based Education, Nanaimo, BC, May 1986.

Peel, C.P., A.R. Collen and P.C. Maydan. "Post-Secondary Applications in Teaching with Computer-Based Networks: Computer Integrated Campus Education and Computer Integrated Distance Education." A paper presented at **The World Congress on Education and Technology**, Vancouver, BC, May 1986a.

Peel, C.P., A.R. Collen and P.C. Maydan. "Assessing Mental Health Aspects of Computer Networking in Higher Education." A paper presented at the **International Conference on Mental Health and Technology**, Vancouver, BC, June 1986b.

Petruk, M.W. "An Alberta-wide School-based Laboratory for Instructional Computing." A paper presented at the **Fifth Canadian Symposium on Instructional Technology**, Ottawa, May 1986.

Radlow, James. **Computers and the Information Society.** McGraw-Hill Book Company, New York, 1986.

Robinson, Louis. "The Computer: An Enabling Instrument." **Current Issues in Higher Education, 1983/84 Series.** No 1, 3-13, 1984.

Shipp, William S. et al. "Networks of Scholar's Workstations in a University Community." Institute for Research in Information and Scholarship, Brown University, Providence, RI, 1983.

Smith, L.R. "Ontario Initiatives in Educational Software Development." A paper presented at **Fifth Canadian Symposium on Instructional Technology**, Ottawa, May 1986.

Szabo, Michael. "Productivity in Courseware Development: Validation of a Canadian Authoring System." A paper presented at the **Fifth Canadian Symposium on Instructional Technology**, Ottawa, May 1986a.

Szabo, Michael. Address to Committee on Computer-Based Education, Malaspina College, Nanaimo, BC, May 9, 1986b.

Szabo, Michael and Keith M. Bagnall. "OMNISIM: Preliminary Results of a Two-Year Validation Study of a Major Authoring System." A paper presented to the **Association for the Development of Computer Based Instructional Systems**, New Orleans, February 1986.

Toffler, Alvin. **The Third Wave.** Bantam Books, William Morrow & Co., Inc. New York, 1981.

Travers, J.G. "Computers in Education in Alberta: A Strategic Plan." A paper presented at the **Fifth Canadian Symposium on Instructional Technology**, Ottawa, May 1986.

Wilson, Brent G. and Jack R. Welsh. "Something New Under the Instructional Sun: Small Knowledge-based Systems as Job Aids." A paper presented at the annual meeting of the **American Educational Research Association**, San Francisco, CA, April 1986.

Walker, Decker F. and Robert D. Hess. **Instructional Software: Principles and Perspectives for Design and Use.** Belmont, California: Wadsworth Publishing Company, 1984.

Wold, Allen L. and C. Bruce Hunter. **New Webster's Computer Dictionary.** Delair Publishing Company, Inc., 1984.

GLOSSARY

3M A specification which refers to a computer with a minimum of 1 megabyte of RAM, processor speed of 1 million machine instructions per second, and a screen resolution of 1000 by 1000 pixels.

8-bit, 16-bit, 32-bit Refers to the internal design of a computer and describes the amount of information which can be processed in a single unit of time within the processor. Generally, one character is represented by 8 bits. Thus a 32-bit computer can process about 4 times as much data as an 8-bit computer in the same period of time.

alphageometric transmission A method of sending graphics images from a videotex database through codes for individual pixels. This method produces clearer graphics images than alphamosaic transmission can provide.

alphamosaic transmission A method of sending graphics images from a videotex database through small blocks of pixels, transmitted to the screen one block at a time and assembled into a picture by a special decoder.

ANSI (American National Standards Institute) An organization that develops, evaluates and describes industry standards of manufacture and product operation.

artificial intelligence (AI) The branch of computer science concerned with making computers behave in ways that resemble intelligent human behavior.

ASCII (American Standard Code for Information Interchange) The character set used on most microcomputers and on many larger computers. The ASCII set includes binary number codes for 128 printing and non-printing characters. The non-printing characters--STX (Start of TeXt), ETX (End of TeXt), ACK (ACKnowledge) and others--send instructions to printers and communications devices.

authoring language A computer program which enables a non-programmer to create computer courseware with relative ease.

automatic programming An AI technique in which the computer is programmed to write programs.

baud A unit, roughly equal to one bit per second, for measuring the speed at which data is transmitted and received through modems and other communications devices. The baud rate is 300 for the most popular current modems, 1200 for higher-speed models, and typically 9600 for hard-wired transmission.

bit An abbreviation for "binary digit", meaning 1 or 0, and communicated electrically through on or off signals. The bit is the smallest unit of information transfer within the computer, corresponding to the presence (on) or absence (off) of electrical voltage above a certain threshold.

bubble memory A nonvolatile primary memory, based on microscopic magnetizable bubbles.

byte The number of bits used to represent a character. "Byte" and "character" are sometimes used synonymously. In microcomputers, a byte is usually 8 bits.

CAD (computer-aided design) A graphics editor with which a design engineer or other design specialist can modify a design by using computer techniques. CAD is the graphics equivalent of word processing and could be called design processing.

CAI (computer-assisted instruction) Interactive use of computers, computer networks, and computerized educational materials to help students learn.

CAL (computer-augmented learning) Instruction in which computer programs supplement traditional teaching methods.

CAM (computer-aided manufacturing) The use of programmable machines and robots under the control of CAD to manufacture products.

CBL (computer-based learning) Instruction in which computer use is the basic method of teaching.

CBT (computer-based training) See CBL.

CD-ROM (compact disk-read only memory) Small laser disks containing permanent reference information (such as dictionaries, encyclopedias) which can be read by inexpensive read-only laser devices attached to microcomputers. Storage capacities range up to 2 gigabytes.

chip The small wafer of silicon or another semiconducting material on which the computer's integrated circuitry is placed. Memory chips store data. A microprocessor, or "computer on a chip", combines memory with logic.

circuit board A fiberglass or plastic resin board containing an assemblage of silicon chips printed with integrated circuits and mounted in a computer. Sometimes called a card or board.

CMI (computer-managed instruction) See CML.

CML (computer-managed learning) The use of computers to assist in the management of classwork or class grading and record keeping.

communications program A program which allows the user to transfer files to and from other computers by means of English-language instructions. Also called a terminal program.

composite video A color graphics system which transmits a combination, or composite, of red, green and blue signals. See RGB video.

CompuServe A general-purpose information utility.

computer conferencing The use of a computer network for the exchange of information, ideas, opinions and proposals among members of a group.

computer literacy The term implies four things: some familiarity with computer terminology, some knowledge of how computers work, some knowledge of the uses to which computers can be put and some basic proficiency in the use of one or more kinds of computer.

computer-moderated conference Another name for computer conferencing, appropriate because the host computer--the large computer whose memory holds the conference mailbox--acts as a moderator in the exchange of opinions.

context data The accumulated mass of facts generated and inferred by the knowledge base of a fifth-generation computer in the course of solving a problem.

courseware Computer programs used for instructional purposes.

database A library of facts and statistics stored in a computer from which information needed by institutions or individual persons can be retrieved.

database management system (DBMS) An interactive software package designed to work with a collection of data files to provide access to, security for and accounting of the use of those files.

dial-up connection A computer connection to another computer via the telephone lines, using a modem.

disk drive A peripheral device, connected to the processor of a computer and containing a read-write head which, on instructions from the processor, will write on a disk by magnetizing small segments of it or read from the disk by detecting the presence of magnetized and nonmagnetized particles.

distributed network A network which has computer systems at a number of locations linked to a large central computer system and to each other.

dot matrix printer A printer which produces characters by transferring ink to the paper a dot at a time. The term usually refers to the impact dot matrix printer, but the thermal printer and the ink-jet printer are also dot matrix printers.

download To send a file from a large computer to a microcomputer.

dumb terminal A keyboard-and-screen combination whose only function is to communicate with a computer.

electronic mail The sending of written messages through an electronic communications network, either within an organization's local network or through external carriers (such as phone lines) to other networks or users.

electronic publishing Public distribution of documents by electronic means.

expert system A computer or computer program dedicated to some narrowly specialized field, such as a specific branch of medicine, in which it has all the available knowledge and the ability to make a diagnosis.

fifth-generation computer A new type of computer, still under development, consisting of three major components: a knowledge base, an inference engine, and the context data. All the computers of the present time are collectively known as fourth-generation computers.

firmware Unchangeable software permanently recorded on ROMs that are built into the computer.

floppy disk A secondary-memory storage medium in the form of a thin, circular piece of plastic coated with magnetizable iron oxide particles and enclosed in a square vinyl envelope for protecton. It is called

"floppy" because the disk proper is no more rigid than photographic film.

fourth-generation computer A computer that uses VLSI (very large scale integrated) circuits, i.e. today's typical computer.

gigabyte Generally, one billion bytes. More accurately, 2 to the 30th power, or 1,073,741,824 bytes.

hard disk A magnetic storage disk that is rigid, or "hard," in contrast to the physical flexibility of the floppy disk. The hard disk stores far more data than the floppy, and access is far more rapid.

host computer The principal computer in a network, to whose processor other computers are connected as terminals.

hypermedia The logical extension of hypertext is hupermedia. An author may link a variety of different media--artwork, photographs, video, voice and sound, high-resolution (color) graphics, music--to form a dynamic electronic document that engages all the senses.

hypertext Software which permits an author to construct a document with branch points or links to other documents, local or remote. For instance, rather than provide footnotes that offer only references to documents, the author can create links to the original sources.

icon A small picture of a familiar object shown on the screen in the programs of some microcomputers. Each picture corresponds to some keyboard command; for instance, a picture of a trash basket corresponds to ERASE FROM MEMORY or DELETE. Computers which display icons usually have a mouse to activate the icon and instruct it where to operate. See mouse.

inference engine The program in a fifth-generation computer which provides the methods for drawing inferences and obtaining solutions to a particular problem.

information utility A computer service specializing in providing a wide range of information and communications services to users who obtain access through their own computers via the telephone and data networks.

ink-jet printer A printer which forms characters by spraying dots of liquid or powdered ink onto the page.

intelligent network A network able to do computer-speed translations between programming languages, graphics standards and microprocessor instruction sets that are otherwise totally incompatible with each other.

intelligent terminal A terminal with a programmable processor enabling it to perform computer operations other than input and output. A microcomputer linked to a host computer through a network is an intelligent terminal. Contrast dumb terminal.

interactive communication Carrying on a dialogue with another computer through the keyboard.

interface The hardware and/or software that connects one system or device to another, either electronically or physically.

K An abbreviation for the prefix "kilo", meaning 1000. When used as a unit of computer storage capacity, K means 2 to the 10th power, or 1024 bytes.

knowledge base A knowledge base contains all the facts in a given field of knowledge and thus is similar to a database. In addition, however, it has a means of determining interrelationships among the facts and drawing inferences from these.

LAN (local area network) A communication hookup of computers and terminals within an organization or among a limited number of users.

laser disk A secondary-memory storage medium in which a laser records information by burning pits in a disk and then reads the information by detecting the pits. Laser disks store data at a far higher density than magnetic disks, and the laser beam accesses data far more rapidly than a magnetics disk's read-write head.

laser printer A printing device that places images on a rotating drum using a laser beam. The drum picks up a toner powder on the laser exposed areas. These areas on the drum are pressed and fused into the paper forming the characters.

Luddites Displaced English weavers who in the early nineteenth century sabotaged the weaving machines that had displaced them. The name has become synonymous with militant technophobia.

magnetic tapes A secondary-memory storage medium similar to the tapes used in cassette recorders, but of much greater capacity. The industry standard for magnetic tapes is 2400 feet wound on a 10-inch reel, the equivalent in storage capacity of several hard disks.

mainframe computers Very large computers with great storage capacity and very rapid speed of operation.

megabyte Generally, one million bytes. More accurately, 2 to the 20th power, or 1,049,576 bytes.

memory The part of a computer system in which instructions and data can be stored and from which they can later be retrieved. Main memory, also called primary memory or volatile memory, is for temporary high-speed storage and retrieval. Secondary memory, also called external memory, is made up of such recording devices as magnetic tapes and disks; it stores the results of operations that have been performed in main memory.

microcomputer The smallest member of the computer family. The processor is entirely contained on a single chip. It is the computer most characteristic of the present generation of computers.

minicomputer A general-purpose computer, smaller and less powerful than a mainframe, but with similar multiuser capability.

modem (modulator-demodulator) A communications device for transmitting and receiving digital signals over telephone lines. It modulates the computer's digital transmission into communications signals and demodulates a telephone line's transmission into digital signals. In microwave communications, a similar device modulates digital into microwave signals and demodulates received microwave transmission into digital signals.

motherboard In a computer, the slotted circuit board into which all the other circuit boards are fitted.

mouse An input selector device; as it moves about on a flat surface, its movements control an onscreeen pointer and other input functions.

MS-DOS (Microsoft-Disk Operating System) The non-proprietary operating system marketed by Microsoft, the firm which produced PC-DOS for IBM. It is the operating system most frequently used by manufacturers of IBM compatible personal computers.

multi-tasking Using a single processor to execute a number of programs at the same time. The different programs take turns at being executed by the central processing unit.

multi-user Using the same processor to serve several different users at the same time. Each user is connected to the processor through a terminal, and the processor divides its time among the users, spending fractions of a second with each in turn. To each user it appears that the processor is serving his/her needs only, unless the system is overloaded.

NAPLPS (North American Presentation Level Protocol Syntax) A communications standard for encoding text and graphics, developed by AT&T and used in its alphageometric transmission technology.

NATAL (NATional Authoring Language) A Canadian-made CAL authoring language developed originally by the National Research Council.

operating system A program that controls the execution of the other programs that run on a computer. The operating system inputs user instructions, tells the computer what steps to follow to store data and communicate with other devices, calls up language processors, executes programs, and carries out such system commands as copying and erasing files. In a timesharing system, the operating system allocates computer resources to different users in turn.

PC-DOS (Personal Computer-Disk Operating System) The operating system used by IBM for its personal computers.

pixels The dots, or picture elements, on a computer screen, which make up the lines, shapes, drawings, numbers and letters created by the computer and displayed on the screen.

PLATO (Programmed Logic for Automatic Teaching Operations) The oldest CAL network, offering a variety of computerized educational programs for all levels.

port A point of connection for communications lines joining the computer to external devices--other computers, printers, modems, other communications lines.

primary memory That part of a computer's memory which is built into the computer and is immediately available to the processor when the computer is turned on. It is sometimes called main memory. All computer operations are performed in primary memory.

RAM (Random-Access Memory) Memory in which any item of information can be accessed without reference to the other contents.

raster graphics Graphics produced on a CRT that uses raster scan image technology.

raster scan A display technology in which an electron beam draws horizontal lines of dots across the screen.

RGB video A graphics screen on which each pixel can receive red, green and blue on/off signals.

RGB video board The special integrated circuit board with which a computer must be equipped for RGB video . The RGB board gives the display memory separate red, green and blue memory segments.

ROM (read only memory) Semiconductor memory that contains programs, instructions or data that cannot be erased by overwriting or loss of power.

RS232 interface A serial port which sends and receives data in accordance with the RS232 (Recommended Standard 232) specifications. Most serial cards incorporate an RS232 interface for communication with external devices that follow the same standard.

serial port A connector through which data enters and leaves the computer one bit at a time; the RS232 interface is an example.

serial transmission The sending of data serially, or one bit at a time, as occurs in communication between a computer and a modem or a serial printer and in all long-distance transmissions.

supercomputer the largest, fastest and most powerful computer in existence at any given time. Supercomputers are used for scientific purposes, for worldwide meteorological calculations, and in creating state-of-the-art graphics.

telecommunications (1) The transmission of data between computers in different locations. (2) Networking from the communications system point of view, which sees the computers in the network as no more than switching devices.

Teletext The name of an American videotex system, developed by NBC, which uses the alphamosaic transmission method.

Telidon The name of a Canadian videotex system.

The Source A general-purpose information utility.

thermal printer A printer which produces characters by burning small dots onto specially treated paper.

touch screen A computer screen which has been modified to accept some instructions communicated by a touch of the user's finger to the screen, as well as instructions communicated through the keyboard.

tutorial A sample session in a word-processing or other applications program in which the user is taught the skills necessary for efficient use of the program.

upload To move data from a microcomputer or terminal to a large computer.

user-friendly Comprehensible to the person using the computer.

vector graphics The technique of drawing on the screen with vectors, or lines drawn by moving the cathode ray across the screen continuously. To be distinguished from raster graphics.

video disk technology the integration of microcomputer technology with existing video disks (see laser disk) to produce effective and exciting lessons. Each of some 58,000 fromes on each side of a video disk can be individually accessed to illustrate lessons with high-quality still photographs or film clips.

videotex An interactive information utility which transmits pictures as well as text. It is therefore well suited to electronic mailorder services.

VLSI (very large-scale integrated circuitry) The packing of hundreds of thousands of integrated circuits onto a single chip. VLSI technology is very important for supercomputers and fifth-generation computers.

voice recognition In computers, the ability to understand human speech.

voice synthesizer A microporcessor-based device which translates typed or printed English text into speech.

WAN (wide-area network) A network interconnecting computers in different cities, states or countries. The telephone network is often used for such purposes.

WORM (write once, read many) A laser disk device upon which it is possible to write, one time only, permanent information and which may then be used to access the information whenever desired.

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